IMPORTANCE OF BIO-ENGINEERING

-**Kalyan Thapa**

Soil erosion occurs whenever water meets land with enough force to move soil. Often this occurs along mountainous slopes of open ground in road and stream river banks or where excess water flows over hill slopes. While hill slope erosion can be dramatic, especially after large rainfalls or floods, normal streamflows, excess runoff from urbanized areas and rain action along hill slope continually erode soil. Erosion can be severe, as is the case in many man-made infrastructures, where materials are composed of easily erodible soil. Traditional methods of controlling streamflow and water induced erosion have relied on structural practices like rip rap, retaining walls and sheet piles. In many cases these methods are expensive, ineffective or socially unacceptable. An alternative approach is Bioengineering, a method of construction using live plants alone or combined with dead or inorganic materials, to produce living, functioning systems to prevent erosion, control sediment and provide habitat. Bioengineering uses combinations of structural practices and live vegetation to provide erosion protection for hillslopes and streambanks. Bioengineering is a diverse and multi-disciplinary field, requiring the knowledge of engineers, botanists, horticulturists, hydrologists, soil scientists and construction contractors. It is a rapidly growing field, subject to innovations and changing design specifications. Terms such as biotechnical erosion control, biostabilization or soil-bioengineering are often used synonymously with bioengineering.

History

The use of bioengineering methods dates back to 12th century China, when brush bundles were used to stabilize slopes. In the early 20th century, similar techniques were used in China to control flooding and erosion along the Yellow River. In Europe, especially Germany, bioengineering methods have been used for over 150 years. Documented use of bioengineering in the United States dates to the 1920s and '30s. Streambank stabilization, timber access road stabilization and slope restoration were common applications. After World War II, with increased access to earth-moving equipment and the development of new structural slope stabilization and erosion control methods, bioengineering practices all but disappeared. In the last 20 years bioengineering has been recognized as a re-emerging technique to provide erosion control, environmentally sound design and aesthetically pleasing structures. Gray and Leiser (1982) published the first U.S. textbook on bioengineering: *Biotechnical Slope Protection and Erosion Control*.

The use of Bioengineering in Nepal has been developed since its introduction in the Dharan-Dhankuta road project in the mid-1980s for the protection of roadside cuts slope. More importantly, the bio-engineering approaches were adopted in project not as an alternative to civil engineering measures but as an integration of vegetative methods with normal engineering practice. While operating Bio-engineering techniques, there are considerable costs saving from 50-70 percent in road maintenance cost (Sunwar and Shrestha 1995). There is standard manual on Bio-engineering published under Department of Roads (DoR): Roadside Bio-engineering both Reference Manual and Site Hand book, John Howell (1999).

Applications, Advantages and Limitations

Bioengineering solutions can be adopted in many soil stabilization and erosion control situations from streambank, River scour and Roadside slopes protection to upland gully restoration and slope stabilization. Bioengineered restoration of flood or high water damage to streams and roads provides a more natural-looking solution than traditional concrete structures.

Advantages of bioengineering solutions are: 1) low cost and lower long-term maintenance cost than traditional methods; 2) low maintenance of live plants after they are established; 3) environmental benefits of wildlife habitat, water quality improvement and aesthetics; 4) improved strength over time

as root systems develop and increase structural stability; and 5) compatibility with environmentally sensitive sites or sites with limited access.
Limitations to bioengineering methods include: 1) the installation season is often limited to plant dormant seasons, when site access may be limited; 2) the availability of locally adapted plants may be limited; 3) labor needs are intensive and skilled, experienced labor may not be available; 4) installers may not be familiar with bioengineering principles and designs so up front training may be required; and 5) alternative practices are aggressively marketed and often more widely accepted by society and contractors.

Bioengineering Techniques

It is required to work in difficult environmental circumstances or professionals interested in natural restoration of landscapes will find useful bioengineering techniques. New methods of application and materials being developed will result in new and improved bioengineering design.
Bioengineering involves the use of live plants to add structural strength to soil. Many different plant materials are used. Live cuttings should be soaked in cold water for at least 24 hours before they are used. This not only provides the cuttings with needed moisture but also improves rooting. Live potted raised plants are often used. Care of live plants before and during planting is critical for success. Live plants raised in Nursery need to be acclimatized to the outdoor environment before planting.
Seeding can be used where appropriate. Seeding and mulching are not appropriate in areas of flooding, high water flow or rapid changes in water depth, as the mulch and seed will be washed away. Proper seedbed preparation, fertilization and irrigation may be needed to assure seedling survival.
Expect some failure of plantings in all bioengineering application. A 75 percent to 80 percent survival rate is considered very good. Replanting is generally inexpensive and often the plants will reestablish themselves in time. Some loss of vegetation does not seriously impact a project as long as most of the soil stays in place and the structural features of the design are sound.

The following practices of bio-engineering technique have found suitable for restoration of natural erosions:

- Grass planting and seeding.
- Tree and Shrub Planting and seeding.
- Large Bamboo planting.
- Brush layering, Fascines and Palisades construction.
- Live check dams and vegetated stone pitching.
- Jute netting and Mulching.

Protect Plantings

Protect Bio-engineering plantings works from both animals and humans are essential to successfully perform the bio-engineering functions against erosion. Signs may keep people away, but the area should be fenced or looked after by watchers. Also, protection from forest fires and cultivation inside the plantation area are important to establish all bioengineering plantings. Be sure surface drainage and water flow is directed away from the new plantings or protected slope.

Vegetation Type

Selection, procurement and installation of the proper plant material are essential for a successful design. Native vegetation existing at or near the site will give good guidance concerning plant selection. As mentioned, live cuttings are often used for wattles and live cuttings. Proper species selection is important. Plants need not be native, but should be well adapted to the region. The use of introduced species allows the potential for increasing the number of different species available.

The availability of plant species, in the appropriate size and quantity, is often a limiting factor in the final selection process. Local nurseries may not carry the types of Bio-engineering plants needed. They may be able to propagate the species needed, but this will take 12 to 18 months. A compromise between use of native species and what may be locally or regionally available will be needed to develop a successful design. Consult horticulturists and botanists for plant selection assistance

Improving Success with Bioengineering

Bioengineering can be effective in many soil erosion situations, but it will not solve all soil erosion or slope failure problems. The success of a project hinges on many factors including proper design, plant selection, proper installation, and weather conditions and outside factors like animal or human damage. Site evaluation is important to determine whether there is adequate sunlight, soil type and water quality to support vigorous plant growth. Do not expect bioengineering solutions to stop slope failure caused by high water tables or landslides. Nor are they ideal for high stress areas with severe water action, rapid or long-term water level fluctuations or fast water flows. The following list includes tips that may help ensure a successful bioengineering project.

1. Do not attempt bioengineering solutions in situations where: 1) there is severe soil or water contamination; 2) the stream bottom is degrading; 3) you can not control human or animal traffic at the site; or 4) there is too much shade for selected plant species to thrive.
2. Water elevation is the most critical element in a successful installation. Be sure you know the normal; high and low water elevations for the site. Know the seasonal changes in water elevation and how rapidly these changes occur.
3. Be sure to fence out animals and people, if needed. If damage occurs, supplemental planting may be necessary.
4. Be aware of flood or drought conditions that could impact your installation. Severe weather will reduce seedling survival. Supplemental planting may be needed.
5. Provide regular monitoring and maintenance, especially in the first year, to assure adequate plant survival.
6. Plan ahead. Involve the proper design professionals and experts to provide information on hydrology, plantings and structural design. A multi-disciplinary approach will assure success.

When to Seek Expert Help

There are bioengineering consultants available to help with all aspects of site assessment, design and installation. Their input could make the difference between success and failure. Many bioengineering techniques can be used successfully without input from consultants, however it is best to consider expert help if characteristics of your site are such that:

1) risk of shallow slumps or planner slips of less than 500mm depth;
2) slope heights and angle are similarly more than 100meters and greater than 45degrees;
3) There is risk of surface drainage, gullying and material slumping.

Tips for a Successful Demonstration

Demonstration projects can help show the advantages and benefits of bioengineering solutions. Keep demonstration projects small, from 100 to 500 feet in length for most situations. A smaller project puts less property and monies at risk. A demonstration lets you evaluate what methods or plant species perform best under similar conditions. Incorporate some variety into the project so you can compare differences. To start, choose a simple project, in a low impact area, with a low profile or incorporate some bioengineering methods into larger projects and collect data to evaluate their success. Provide adequate maintenance and keep good monitoring records. Schedule agency personnel and public visits to the site to maximize public relations. Plan to hold these visits during installation and again after one growing season.

Reference:

1. *Bio-engineering Guide lines for Slope Stabilization, DSC/WMP, 1997*
2. *Construction site Erosion and Sediment Control, WSDOT, 2002*
3. *Low Cost Engineering and Vegetative Measures for Stabilizing Roadside Slope in Nepal, International Conference on Vegetation and Slopes, Oxford ,UK, Lawrance,C.J,1994*
4. *Roadside Bioengineering, Reference Manual and Site Hand Book, John Howell,1999*

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Biological engineering, or bioengineering/bio-engineering, is the application of principles of biology and the tools of engineering to create usable, tangible, economically viable products. Biological engineering employs knowledge and expertise from a number of pure and applied sciences, such as mass and heat transfer, kinetics, biocatalysts, biomechanics, bioinformatics, separation and purification processes, bioreactor design, surface science, fluid mechanics, thermodynamics, and polymer science. It